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Phytotoxicology Assessment Survey Investigation in the Vicinity of CAMCO, Hamilton - 1990

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Background

CAMCO is a large manufacturer of home appliances in the city of Hamilton. Appliances that require a porcelain finish are sprayed with an enamel which may contain fluoride, boron and a number of other elements. Excess spray materials from the process are exhausted into the atmosphere in gaseous and particulate form.

Because of the potential for boron and fluoride to injure vegetation and contaminate soils, the Phytotoxicology Section has conducted annual surveys of vegetation and/or soils in the vicinity of the plant since 1983. Survey results indicated that little or no injury could be attributed to the emissions. However, a fluoride concentration in excess of the Phytotoxicology Upper Limit of Normal (ULN) guideline was found in unwashed foliage at one site close to the factory. Excessive boron concentrations were found in washed and unwashed vegetation at many sites from 1985 to 1987. No survey was conducted in 1988. In soils, excessive total boron values have been detected at virtually all sites since 1983. Available boron (determined by the hot water extraction method) above 1 ppm was found in soils at 6 survey sites in 1987. This level of available boron in soil is considered to be phytotoxic.

Since 1987, components that contain boron have been eliminated from the production process at the CAMCO plant. Although current emissions of boron have been curtailed, vegetation in the survey area will continue to absorb boron from the soil for several years. As a result, the Phytotoxicology Section will maintain the regular surveillance program to monitor boron values in foliage and soils.

Phytotoxicology Surveillance

In order to monitor the residual effects of boron contaminated soil on vegetation in the vicinity of the CAMCO plant, the annual Phytototoxicology surveillance was continued in 1990. This was the first survey since boron was eliminated from the manufacturing process

in 1987. On 5 September 1990, Mr. G. Vasiloff visited the area and examined and sampled vegetation at 13 established sites around the CAMCO plant. The locations of the survey sites, and their proximity to CAMCO, are shown in the attached map (Figure 1).

At each site, foliage was examined and visible injury was evaluated and recorded. Foliar injury observed at most sites was attributed to insect and/or disease agents. Boron-type foliar injury was observed at only 2 of the survey sites. At Site 3, 11-35% terminal, marginal and intercostal foliar injury was noted on a honey locust tree. Less severe (2-10%) terminal and marginal injury was observed on Manitoba maple foliage at Site 9.

Following the observational phase of the survey, a duplicate sample of examined foliage was collected for chemical analysis from each survey site. All foliar samples were collected from the portion of the tree crown facing the industry. The samples were delivered to the Phytotoxicology laboratory in Toronto for processing prior to analysis. Samples were processed unwashed, according to standard procedures, and submitted to the Ministry's Inorganic Trace Contaminants Laboratory to be analyzed for boron, fluoride and 11 other elements.

Chemical Analysis Results

Boron

Boron values detected in foliage during six annual sampling periods between 1983 and 1990 have been assembled in Table 1. Values of the element that are in excess of the Phytotoxicology Upper Limit of Normal (ULN) guideline for urban foliage appear underlined. The rationale for the derivation and use of the ULN guidelines is provided in the Appendix.

Boron values in excess of the ULN guideline (175 ppm) were detected in the 1990 foliage at 4 of the 13 surveillance sites. In 1987, excessive values were found at 8 sites. Only 3 exceedences were detected in the 1986 survey foliage. The highest (since 1983) boron value (1050 ppm) was found in Manitoba maple foliage at Site 9 in 1990.

Boron values detected in Manitoba maple foliage at all survey sites (honey locust was utilized at Site 3 and silver maple was substituted at Site 12), were plotted in a computer-generated program (Surfer - Golden Software, Inc., Golden Colorado) to produce a contamination contour map (Figure 2). Although the contour values (lines) at each survey site are placed accurately, the configurations of the lines between sites are computer-generated extrapolations of where the lines should be, based on the data. The contour map clearly demonstrates that the CAMCO plant is central to the high boron values detected in the vegetation, and that values decrease with increased distance from the plant. The map also delineates the area affected above the ULN guideline of 175 ppm. The configuration of the contours suggest that the main deposition was in a northeasterly direction. This is consistent with winds being predominantly from the southwest during the growing season.

Fluoride

Average fluoride values found in 1990 foliage appear in Table 2. Data for the five year period from 1983 to 1987 have been included for purposes of comparison. The 1990 data indicate that only one value in excess of the 35 ppm ULN guideline was detected (Site 9). One excessive value occurred in each of 1986 and 1987 - both at Site 3. Both Sites 3 and 9 are located very close to the CAMCO complex.

A computer-generated contour map (Figure 3) was prepared to demonstrate the relationship between elevated fluoride values and the CAMCO plant. The figure shows that higher fluoride values are clearly associated with the factory and fluoride values decreased with increased distance from the plant.

Other Elements

A number of elements, such as titanium, barium and sodium are often contained in the composition of enamel materials used to coat appliances. In all, a group of eleven other elements was examined in the 1990 CAMCO survey foliage. Analysis results along with established ULN guidelines, appear in Table 3.

With the exception of managanese and copper, values of the other elements were below ULN guidelines. Excessive values of manganese were found at two sites (1 and 2) and copper at one site (3). All three sites, particularly Site 3, are situated within about 200 metres of the CAMCO plant.

Contour maps were constructed to examine the distribution of manganese and copper values found in vegetation in relation to the CAMCO plant (Figures 4 and 5). The position of the CAMCO plant within the manganese and copper contour patterns indicates that CAMCO is the likely source of these two elements.

Conclusions

Excessive levels of boron were found in vegetation at 4 of 13 survey sites in the vicinity of the CAMCO plant in 1990. The 4 sites represent a considerable decline from the 8 in 1987, but the number of sites with excessive values in 1990 is greater than during any period from 1983 to 1986. In 1990, the highest boron value (1050 ppm) in vegetation was found since the inception of the survey in 1983.

Of 11 other elements examined, excessive concentrations of only fluoride (1 site), manganese (2 sites) and copper (1 site) were detected in survey foliage. The 50 ppm fluoride value found at Site 9 was the highest since 1983.

Visible boron-type foliar injury was observed on vegetation at only 2 survey sites in 1990. Although boron is no longer a component in the enamel spray operation, it was concluded that the source of the excessive boron values detected in vegetation was the boron-

contaminated soil. The CAMCO survey report for 1986 and 1987 (Report number: ARB-025-87-Phyto) revealed the presence of phytotoxic levels of available boron in 0-5 cm soils at 8 survey sites.

Provided that the high boron values found in the 1990 vegetation survey occurred as a result of root uptake from the soil, the injury and high foliar concentrations will continue until boron levels in the soil are reduced through natural leaching or remedial measures.

TABLE: 1 Boron Values Detected in Surveillance Foliage Collected in the Vicinity of CAMCO, Hamilton 1983-1990

Survey Site Number	Vegetation Sampled	Distance & Direction from CAMCO	Boron Values (ppm - dry wt) 1983	1984	1985	1986	1987	1990
1	Manitoba maple	200 m N	109	100	--	175	219	145
	White Ash		--	--	8	--	--	--
2	Manitoba maple	200 m NNW	--	--	--	--	--	145
3	Honey Locust	100 m WNW	--	--	94	196	307	355
4	Elm	250 m SSW	92	160	--	--	--	--
	Manitoba maple		--	--	200	173	281	175
5	Silver Maple	300 m SSE	88	100	73	--	--	63
	Manitoba maple		--	--	--	101	214	135
6	Norway maple	400 m SE	104	100	--	--	--	--
	Sugar maple		--	--	77	--	--	--
	Manitoba maple		--	--	--	103	134	87
	Silver maple		--	--	--	--	--	64
7	Norway maple	450 m ESE	89	110	--	--	--	--
	Manitoba maple		--	--	180	113	188	115
	Silver maple		--	--	--	--	--	130
8	Norway maple	1100 m ESE	63	86	--	--	--	--
	Manitoba maple		--	--	70	--	--	91
	Silver maple		--	--	--	--	--	48
9	Apple	300 m NE	--	--	52	--	--	--
	Manitoba maple		--	--	--	590	639	1050
10	Manitoba maple	300 m WSW	--	--	170	166	259	165
11	Manitoba maple	650 m E	--	--	--	163	251	415
12	Silver maple	1000 m ENE	--	--	--	269	51	300
13	Manitoba maple	400 m N	--	--	--	99	62	66

Underlined values exceed the Phytotoxicology Upper Limit of Normal (ULN) guideline of 175 ppm for boron in urban foliage.

TABLE: 2 Fluoride Values Detected in Surveillance Foliage Collected in the Vicinity of CAMCO, Hamilton 1983-1990

Survey Site Number	Vegetation Sampled	Distance & Direction from CAMCO	Fluoride Values (ppm - dry wt) 1983	1984	1985	1986	1987	1990
1	Manitoba maple	200 m	18	7	--	6	16	10
	White Ash		--	--	8	--	--	--
2	Manitoba maple	200 m NNW	--	--	--	--	--	8
3	Honey Locust	100 m WNW	--	--	33	38	41	24
4	Elm	250 m SSW	48	14	--	--	--	--
	Manitoba maple		--	--	12	7	18	5
5	Silver Maple	300 m SSE	18	4	11	--	--	11
	Manitoba maple		--	--	--	7	17	11
6	Norway maple	400 m SE	17	9	--	--	--	--
	Sugar maple		--	--	9	--	--	--
	Manitoba maple		--	--	--	13	14	11
	Silver maple		--	--	--	--	--	11
7	Norway maple	450 m ESE	10	9	--	--	--	--
	Manitoba maple		--	--	9	9	15	5
	Silver maple		--	--	--	--	--	11
8	Norway maple	1100 m ESE	9	7	--	--	--	--
	Manitoba maple		--	--	11	--	--	7
	Silver maple		--	--	--	--	--	10
9	Apple	300 m NE	--	--	29	--	--	--
	Manitoba maple		--	--	--	21	26	50
10	Manitoba maple	300 m WSW	--	--	33	5	9	14
11	Manitoba maple	650 m E	--	--	--	7	13	25
12	Silver maple	1000 m ENE	--	--	--	8	20	10
13	Manitoba maple	400 m N	--	--	--	5	11	6

Underlined values exceed the Phytotoxicology Upper Limit of Normal (ULN) guideline of 35 ppm for fluoride in urban foliage.

TABLE: 3 Values of 11 Inorganic Elements Detected in Surveillance Foliage Collected in the Vicinity of CAMCO, Hamilton 1990

Survey Site Number	Vegetation Sampled	Distance & Direction from CAMCO	Elemental Values (ppm - dry wt) Na	Zn	Pb	Ti	Ba	Mn
1	Manitoba maple	200 m N	57	40	5	19	14	<u>105</u>
2	Manitoba maple	200 m NNW	51	23	3	15	13	<u>105</u>
3	Honey Locust	100 m WNW	99	30	3	19	26	63
4	Manitoba maple	250 m SSW	53	26	1	4	11	53
5	Silver Maple	300 m SSE	220	47	3	19	9	62
	Manitoba maple	300 m SSE	61	30	3	12	11	63
6	Silver maple	400 m SE	20	46	2	13	6	35
	Manitoba maple	400 m SE	37	17	1	9	12	43
7	Silver maple	450 m ESE	24	31	2	11	6	77
	Manitoba maple	450 m ESE	24	18	1	6	9	31
8	Silver maple	1100 m ESE	36	54	1	8	10	26
	Manitoba maple	1100 m ESE	31	21	3	12	14	40
9	Manitoba maple	300 m NE	55	36	2	28	48	54
10	Manitoba maple	300 m WSW	99	24	3	10	9	55
11	Manitoba maple	650 m E	71	35	4	27	11	40
12	Silver maple	1000 m ENE	69	48	4	17	18	56
13	Manitoba maple	400 m N	42	17	2	7	7	60
Phytotoxicology Upper Limit of Normal (ULN) Guidelines for urban foliage.			350	250	60	NE	NE	100

Underlined values are in excess of their respective ULN guidelines.

NE - ULN guideline for this element has not been established.

cont'd....

TABLE: 3 Cont'd

Survey Site Number	Vegetation Sampled	Distance & Direction from CAMCO	Elemental Values (ppm - dry wt) Al	Fe	Cu	Ni	Mg (%)
1	Manitoba maple	200 m N	130	370	4	2	0.5
2	Manitoba maple	200 m NNW	90	300	4	2	0.5
3	Honey Locust	100 m WNW	69	250	23	2	0.3
4	Manitoba maple	250 m SSW	33	190	8	2	0.4
5	Silver Maple	300 m SSE	112	405	9	1	0.4
	Manitoba maple	300 m SSE	110	440	7	2	0.7
6	Silver maple	400 m SE	73	325	7	1	0.3
	Manitoba maple	400 m SE	49	260	5	2	0.6
7	Silver maple	450 m ESE	64	215	6	1	0.4
	Manitoba maple	450 m ESE	46	150	3	2	0.5
8	Silver maple	1100 m ESE	62	185	5	1	0.4
	Manitoba maple	1100 m ESE	64	255	4	2	0.6
9	Manitoba maple	300 m NE	47	155	5	3	0.5
10	Manitoba maple	300 m WSW	72	260	5	2	0.5
11	Manitoba maple	650 m E	130	305	5	2	0.6
12	Silver maple	1000 m ENE	91	310	5	2	0.5
13	Manitoba maple	400 m N	60	245	3	2	0.4
Phytotoxicology Upper Limit of Normal (ULN) Guidelines for urban foliage.			500	1000	20	7	0.7

Underlined values are in excess of their respective ULN guidelines.

Magnesium values are given in percent (%) - dry weight.

FIGURE: 1

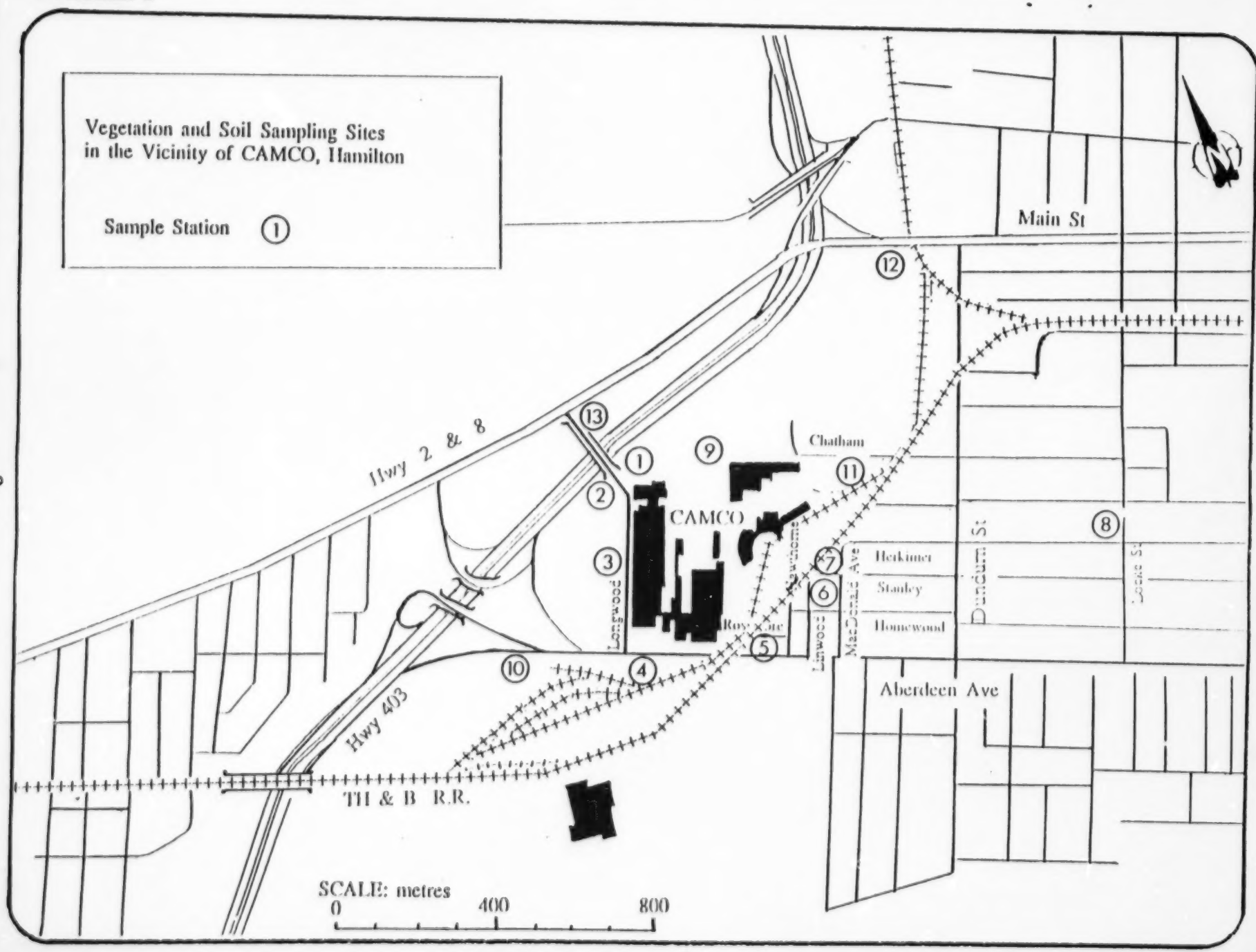
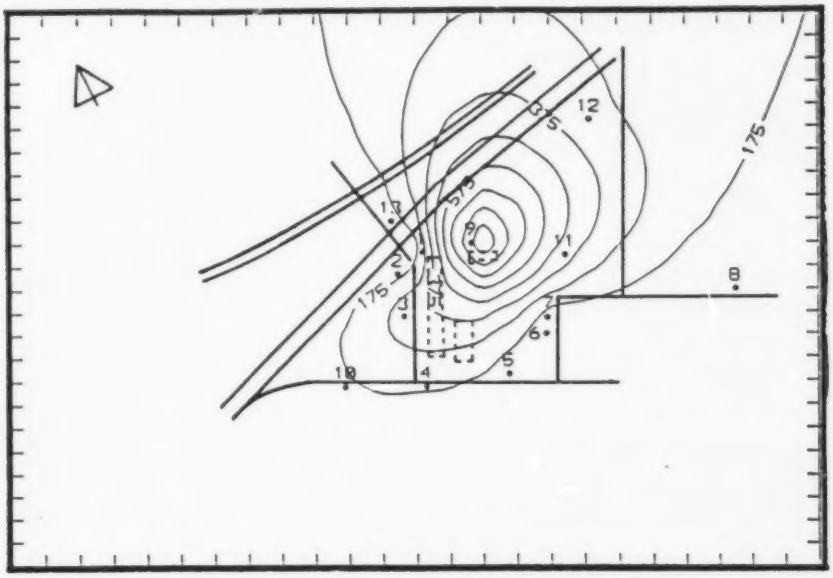
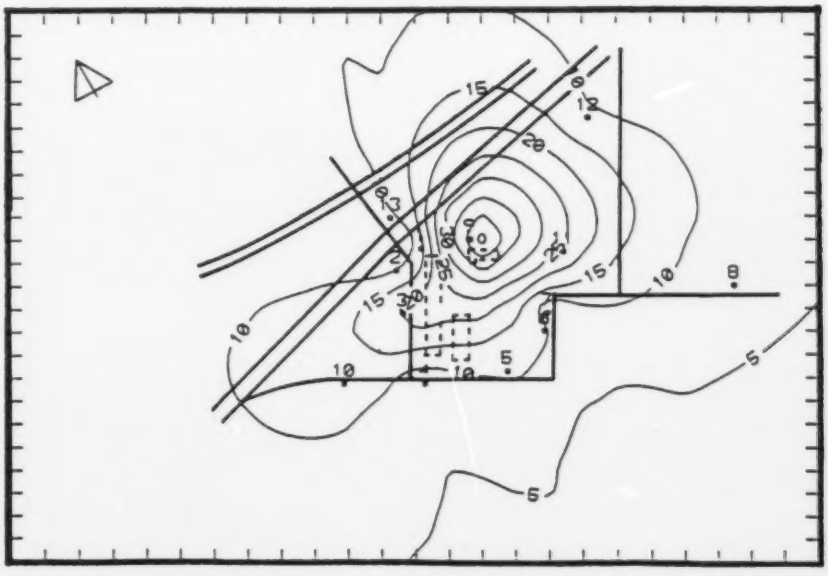

Vegetation and Soil Sampling Sites
in the Vicinity of CAMCO, Hamilton
Sample Station 1
Main St
12
13
1
2
3
9
11
Chatham
CAMCO
Hwy 2 & 8
Longwood
Lawrence
MacDonald Ave
Dundurn St
Lorne St
8
7
6
5
4
10
Heakimer
Stanley
Homewood
Roxborough
Aberdeen Ave
Hwy 403
TH & B R.R.
SCALE: metres
0
400
800

FIGURE: 2 Boron Concentrations in Maple Foliage - Camco, Hamilton - 1990



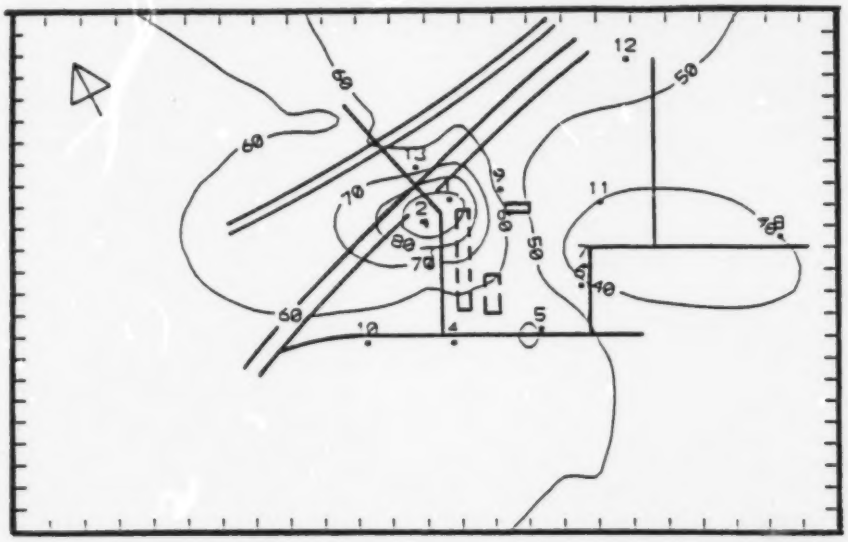
Contour Interval 100 ppm

FIGURE: 3 Fluoride Concentration in Maple Foliage - Camco, Hamilton - 1990



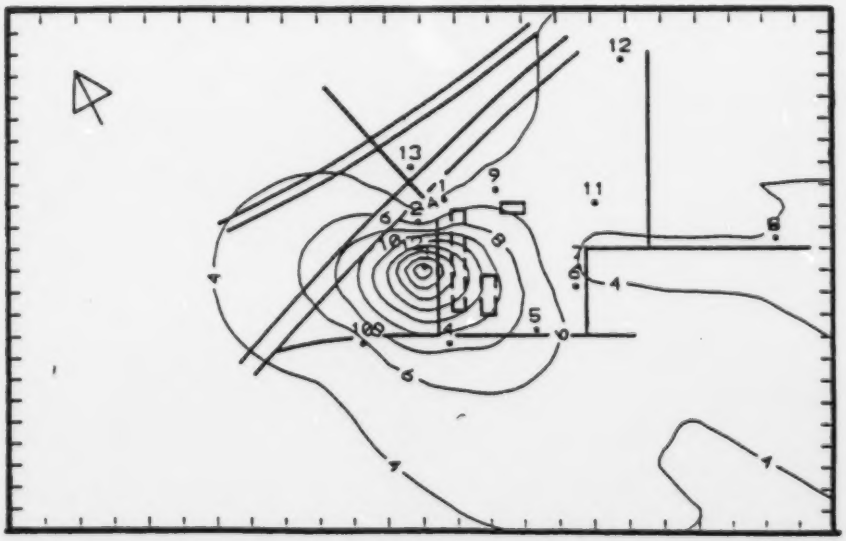
Contour Interval 5 ppm

FIGURE: 4 Manganese Concentrations in Maple Foliage
CAMCO, Hamilton - 1990



Contour Interval 10 ppm

FIGURE: 5 Copper Concentrations in Maple Foliage
CAMCO, Hamilton - 1990



Contour Interval 2 ppm

Appendix

Derivation and Significance of MOE "Upper Limits of Normal" Contaminant Guidelines

The MOE "upper limits of normal" contaminant guidelines essentially represent the expected maximum concentration of contaminants in surface soil (non-agricultural), foliage (tree and shrub), grass, moss bags and/or snow from areas of Ontario not subject to the influence of point source emissions. "Urban" guidelines are based upon samples collected from centres of minimum 10,000 population. "Rural" guidelines are based upon samples collected by MOE personnel using standard sampling techniques (ref: Ministry of the Environment, 1983. Field Investigation Manual. Phytotoxicology Section - Air Resources Branch: Technical Support Sections - NE and NW Regions). Chemical analyses were performed by the MOE Laboratory Services Branch.

The guidelines were calculated by taking the arithmetic mean of available analytical data and adding three standard deviations of the mean. For those distributions that are "normal", 99% of all contaminant levels in samples from "background" locations (i.e. not affected by point sources nor agricultural activities) will lie below these upper limits of normal. For those distributions that are non-normsl, the calculated upper limits of normal will not actually equal the 99th percentile, but nevertheless they lie within the observed upper range of MOE results for Ontario samples.

It is stressed that these guidelines do not represent maximum desirable or allowable levels of contaminants. Rather, they serve as levels which, if exceeded, would prompt further investigation on a case by case basis to determine the significance, if any, of the above normal concentration(s). Concentrations which exceed the guidelines are not necessarily toxic to plants, animals or man. Concentrations which are below the guidelines are not known to be toxic.